

## COMPARATIVE EGG ECOLOGY OF TWO SYMPATRIC MANTIDS (MANTODEA: MANTIDAE)

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*Abstract.*—We compared numbers and weights of oothecae, hatching success, numbers of eggs and sizes of emerging nymphs of two species of sympatric mantids (*Tenodera sinensis* Saussure and *Mantis religiosa* L.) from two different old field habitats (CHRY and AG). Hatching success and size of emerging nymphs were much greater for *T. sinensis*, whereas numbers of eggs/ootheca were about the same for both species. However, sizes of nymphs varied between oothecae of each species. Numbers and sizes of oothecae for both species were greater at CHRY than AG, probably indicating that the parental generation was less food limited at CHRY.

*Key Words:* Mantodea, Mantidae, *Mantis*, *Tenodera*, egg ecology, oothecae, nymphs, habitats

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Two mantid species which commonly co-occur in northern Delaware are *Tenodera sinensis* Saussure, introduced from the Orient (Laurent 1898), and *Mantis religiosa* L. from Europe (Gurney 1950). These species, which are also sympatric in China (Yan et al. 1981), inhabit old fields of varying successional maturity and vegetational composition in which they segregate by foliage height: *T. sinensis* typically occurs higher than *M. religiosa* (Rathet and Hurd 1983). Oothecae of both species have an aggregated dispersion in the field (Eisenberg and Hurd 1990). Egg hatch occurs at different times in the spring, *T. sinensis* preceding *M. religiosa* (Hurd and Eisenberg 1989b), however both species mature at about the same time late in the summer (Hurd and Eisenberg 1989a). As the size of these predators determines the size of prey which they can handle, the enhanced disparity in body size resulting from asynchronous egg hatch may

serve to alleviate interspecific competition between these two species by reducing overlap in prey size (Hurd and Eisenberg 1990). Such allochronic niche separation also has been proposed as a mechanism for coexistence among plecopterans (Allan 1982).

We undertook a comparative study of aspects of the eggs and newly hatched nymphs of these two species: ootheca size, hatch success rate, and size of emerged nymphs. We compared oothecae from two field sites to examine the influence of habitat differences with respect to these variables.

### MATERIALS AND METHODS

Oothecae of *T. sinensis* and *M. religiosa* were collected from two old field habitats in New Castle County, Delaware, on 26 February 1986. One site, designated AG, was an abandoned hayfield on the Experimental Farm of the University of Delaware; the other site (CHRY), about 3 km distant,

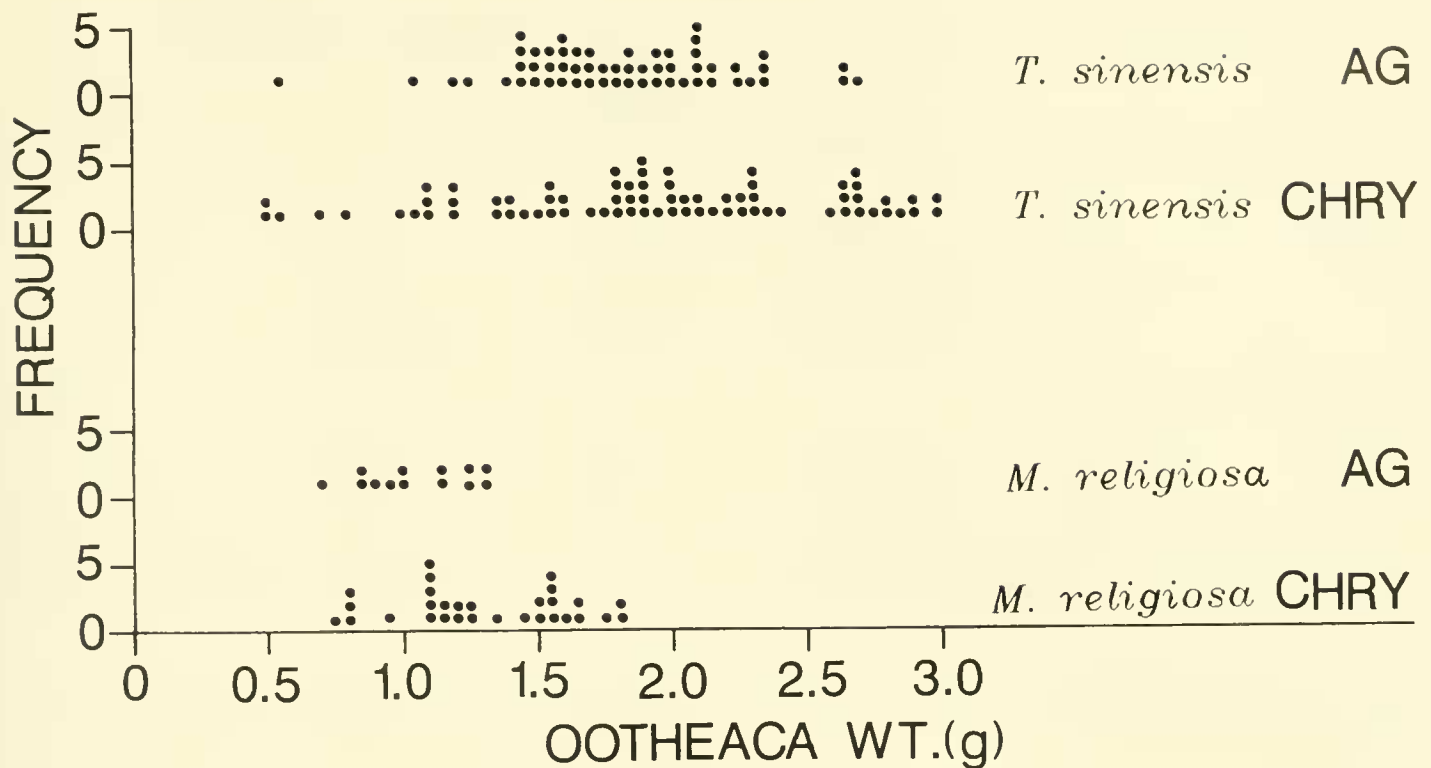


Fig. 1. Frequency (numbers) of live weights of oothecae of *Tenodera sinensis* and *Mantis religiosa* collected from two field sites (AG and CHRY).

was a more mature goldenrod assemblage. Aspects of the comparative ecology of nymphs and adults, as well as the hatching sequence of eggs have been described for both sites (Hurd and Eisenberg 1989a, b).

We carried out standardized time-limited searches (30 min) in each habitat and all oothecae encountered were collected. Oothecae were weighed and 10 of each species from each site, representing the range of weights obtained, were incubated in separate containers at 25°C. Nymphs emerging from these oothecae were counted. Following egg hatch, oothecae were autopsied to determine the proportion of eggs which did not hatch. Dry weights of freshly emerged nymphs were obtained from two or three oothecae from each species and site.

## RESULTS

*Tenodera sinensis* oothecae were more common than those of *M. religiosa* at both sites, and egg cases of both species were more abundant and somewhat larger (especially for *M. religiosa*) in site CHRY than in AG (Fig. 1).

Emergence success of *T. sinensis* was very high (>90%) and very similar in both sites (% hatching, Table 1). Variability in emergence success was very low in both sites for this species (standard errors, Table 1). The values from which these means were obtained ranged from about 85–100% at both sites.

In contrast, *M. religiosa* had lower and more variable hatching success at both sites (Table 1). Variability in emergence success also was 2–7 times greater for this species than for *T. sinensis* (standard errors, Table 1). The values for hatching success ranged from 0–99% in site CHRY, and from 56–96% in AG.

Although *T. sinensis* oothecae in the selected, autopsied sample weighed an average of 1.6 times more than those of *M. religiosa*, the total number of eggs was very similar for both species (Table 1). However, emerging *T. sinensis* nymphs are nearly twice the weight of *M. religiosa* nymphs, with no overlap (Fig. 2). These weights were variable among oothecae for both species, but did not appear to be related either to site or

Table 1. Hatching success and autopsy results for mantid oothecae. Numbers are means ( $\pm$ SE).

Site	Ootheca (g)	Numbers of Eggs			% Hatched
		Total	Unhatched	Hatched	
a. <i>Mantis religiosa</i>					
CHRY	1.36 (0.11)	246.0 (16.16)	61.4 (25.43)	184.6 (27.66)	75.6 (10.34)
AG	1.06 (0.07)	238.7 (11.75)	44.0 (10.69)	194.7 (16.39)	81.4 (4.51)
b. <i>Tenodera sinensis</i>					
CHRY	1.90 (0.22)	252.1 (24.10)	13.5 (3.28)	238.6 (22.97)	94.2 (1.34)
AG	1.95 (0.14)	262.0 (17.49)	13.5 (4.51)	248.5 (18.05)	94.6 (1.78)

weights of oothecae from which they came (Fig. 2).

#### DISCUSSION

Evidently site CHRY was better than AG for the parental generation of both species, based upon weights and numbers of oothecae. Both of these variables translate into greater numbers of eggs oviposited at CHRY, undoubtedly as a function of greater food supply for adults there (Eisenberg et al. 1981, Hurd 1989). However neither hatching success nor weight of emerging nymphs was affected by site. Therefore feeding condition of the adult may not determine size or hatching success of the eggs. Alternatively, the differences in these variables might be a function of the variability in feeding success among parental individuals. This kind of variability could have been caused by differences in capture success among juveniles in the parental generation, which can lead to variable rates of development among nymphs (Hurd and Eisenberg 1984, 1989a, Hurd and Rathet 1986), as well as to differences in body size and consequent fecundity of adults (Eisenberg et al. 1981, Fagan and Hurd 1991). Another factor which generates variability within a mantid population is timing of egg hatch with respect to changing ambient conditions during the spring: developmental rate of

nymphs is highly dependent upon temperature (Hurd et al. 1989).

It is evident from our data that hatching success for *M. religiosa* eggs is lower than for those of *T. sinensis* at both sites. Eggs of the former species require a cold diapause (Salt and James 1947), whereas those of the latter do not: we routinely have hatched *T. sinensis* eggs in the laboratory without having subjected them to other than room temperature. The winters in Delaware may be too mild for eggs of *M. religiosa*, which have a more northerly distribution than *T. sinensis*.

The fact that first instar nymphs of *M. religiosa* are smaller than those of *T. sinensis*, and that they hatch later in the spring (Hurd and Eisenberg 1989b) than those of *T. sinensis* creates a difference in sizes that may reduce interspecific competition (Hurd and Eisenberg 1990), enabling coexistence in the same habitat. However this disparity in size also may encourage interspecific predation on the smaller species by the larger (Hurd 1988). Since both hatching time and sizes of emerging nymphs also vary within each of these species, intraspecific competition also may be reduced and/or cannibalism encouraged in these populations.

Although ootheca weight in mantids is strongly related to the number of eggs contained therein (Eisenberg and Hurd 1977),

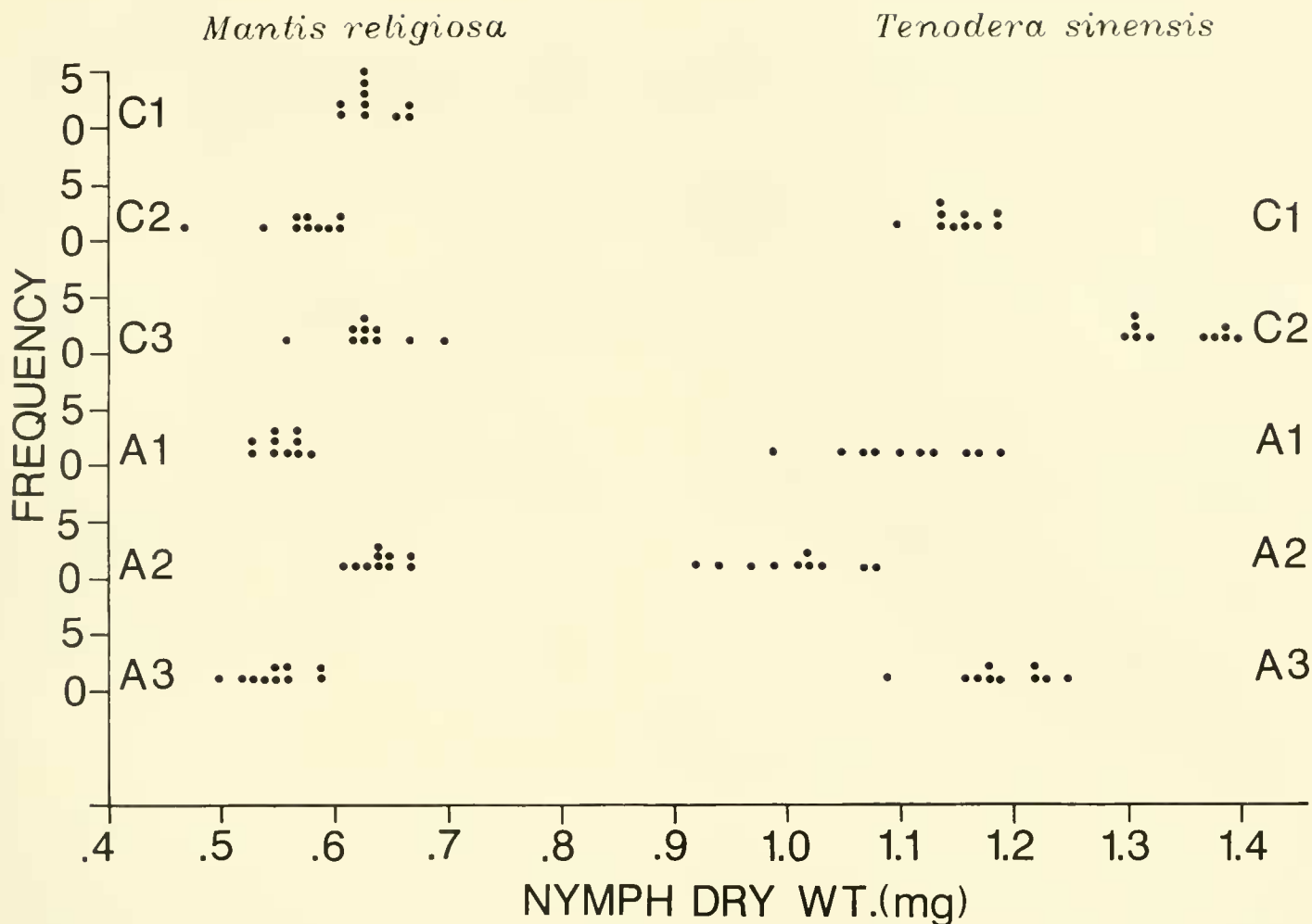


Fig. 2. Frequency (numbers) of dry weights of first instar nymphs of *Mantis religiosa* and *Tenodera sinensis* from two field sites (AG and CHRY). A1–A3 refer to oothecae from site AG; C1–C3 are oothecae from CHRY. N = 10 nymphs for each ootheca.

sizes of emerging nymphs of both species in our study were not related to sizes of oothecae. It is therefore possible that variability in egg size is a function of genetic variability within and between populations. What remains to be determined is whether or not there is a correlation between size of an emerging nymph and its fitness: does a larger first instar nymph have a greater chance of survival and/or greater eventual fecundity than a smaller one?

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